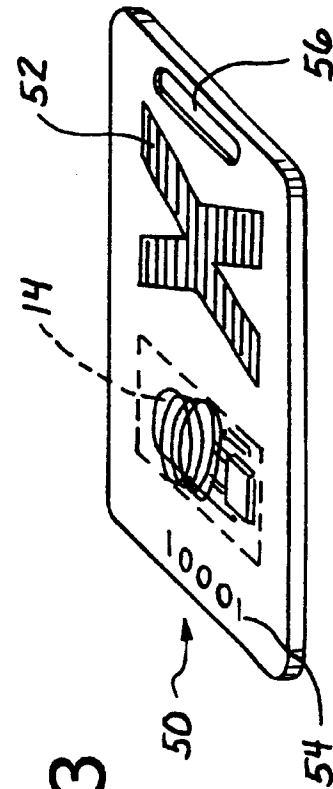
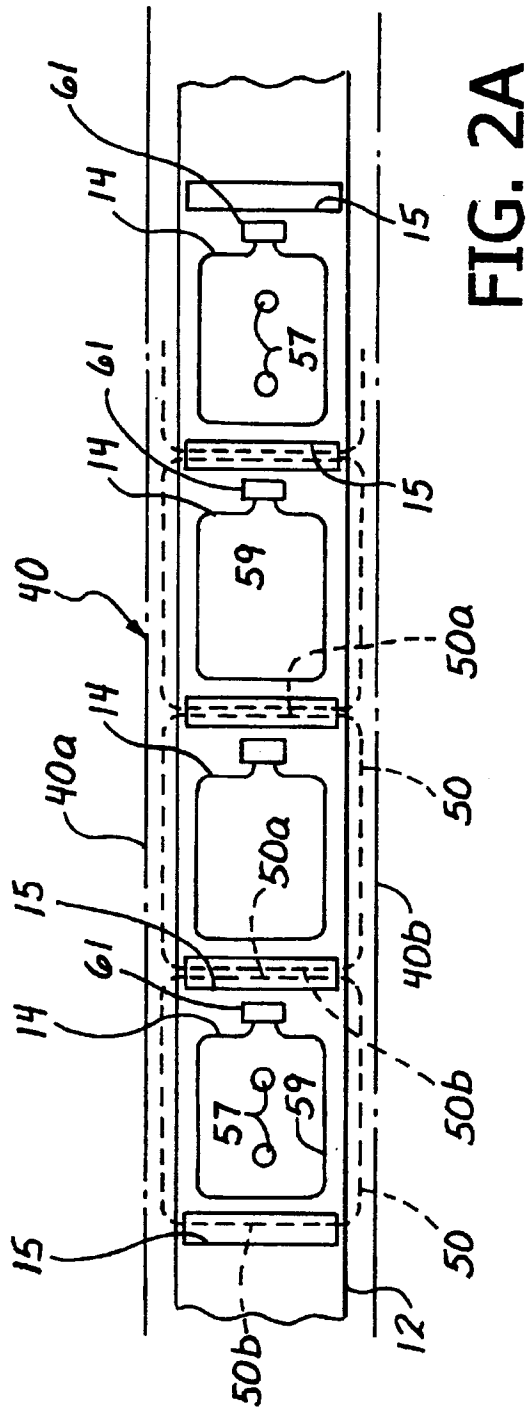


# TAB J

# PART 11

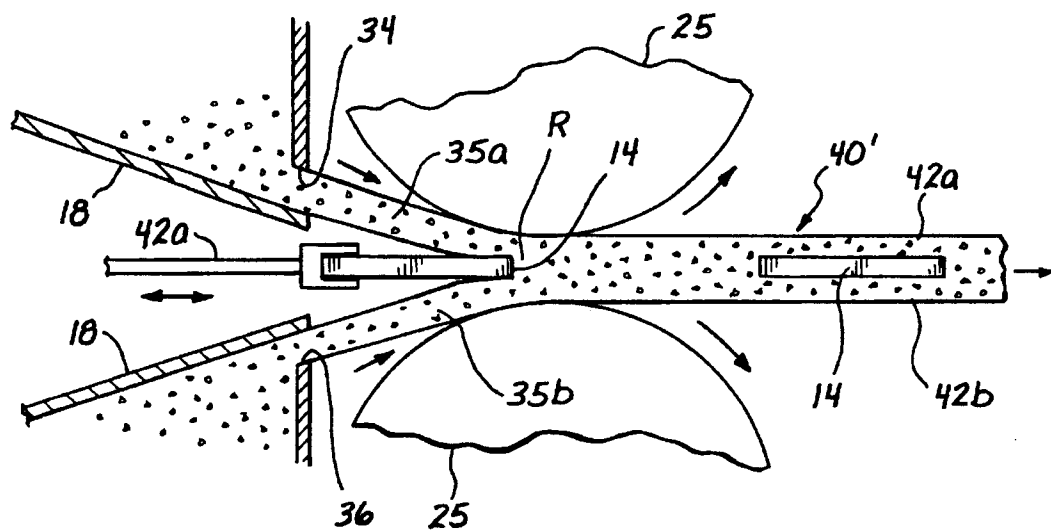
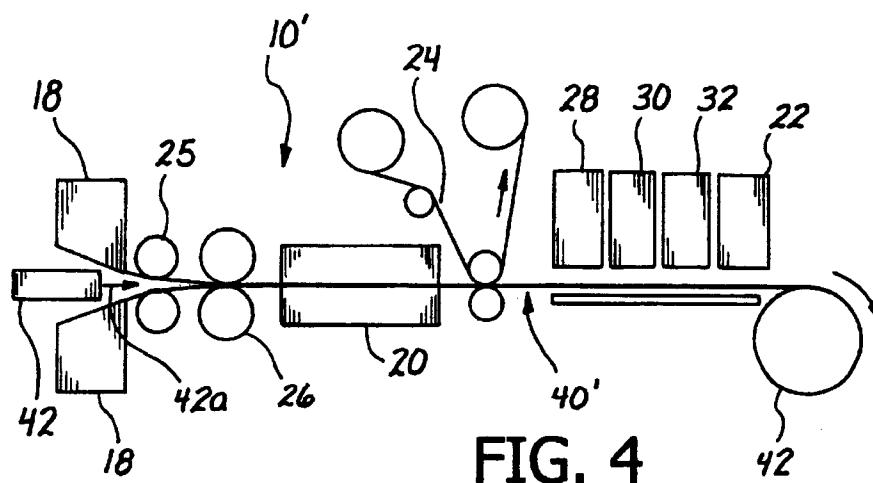


U.S. Patent

Jun. 19, 2001

Sheet 3 of 3

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**METHOD FOR THE CONTINUOUS  
FABRICATION OF ACCESS CONTROL AND  
IDENTIFICATION CARDS WITH  
EMBEDDED ELECTRONICS OR OTHER  
ELEMENTS**

**BACKGROUND OF THE INVENTION**

**1. Field of the Invention**

This invention relates generally to the field of cards, labels or other planar and laminar structures containing embedded devices interactive with external readers such as electronic access control or identification card readers, and more particularly concerns a method of continuously manufacturing such cards, labels and structures.

**2. State of the Prior Art**

The use of plastic cards as carriers for embedded electronic, magnetic or other interactive devices has grown and continues to grow at a rapid pace. Early key cards contained magnetic coding elements such as barium ferrite and Wiegand wire elements, and such cards are still in widespread use. These cards are inserted into a card reader unit equipped with appropriate sensors which, upon detecting a correct card coding pattern, grant access to protected premises or equipment to the card holder. Advances in solid state electronics and large scale integrated circuit design have produced relatively complex microcircuits or chips suitable for encapsulation in thin card structures. These chips have greatly increased the capabilities of the cards. One area of improvement has been the incorporation of programmable data storage and data processing in the card, leading to so called smart cards used, for example, as refillable cash cards for consumer purchases. Another area of improvement is the development of radio frequency communication between the card and the card reader, resulting in so called non-contact or proximity cards. A principal application of this technology is in radio frequency identification (RFID) proximity cards which incorporate radio frequency transponder integrated circuits or chips. By combining these two technologies non-contact smart cards have been developed more recently. Furthermore, these technologies are not limited to access control or financial transaction cards. Other uses include interactive labels on shipping or storage crates, pallets and other containers to automate and speed-up routing and processing of goods in transit and inventory control of stored goods. Such labels may be plastic sheet structures containing RFID transponder tag integrated circuit chips which cooperate with proximity tag readers. The labels may be programmable with data such as container content, dates, destination, etc. Other uses for such interactive cards and labels are still being found, so that this invention is directed broadly to laminar assemblies with embedded interactive elements, without limitation to any particular use or application of the laminar assembly.

A great deal of effort and innovation has been directed to the problem of economically manufacturing such plastic carrier cards. The large volume, low cost manufacture of carrier cards with embedded electronic elements is more difficult than may appear at first thought. Standardization of the carrier cards has resulted in tight dimensional tolerances including card thickness. There is also increasing demand for ever thinner cards, approaching the thickness of magnetic stripe credit cards, while still containing the embedded interactive electronics including in some cases microprocessor chips. Along with the dimensional requirements is a demand for high quality appearance and finish of these cards. The ability to deliver a choice of surface texture and

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full color graphics on the card is necessary for competitive participation in this market. Company logos and user information including photographic identification may be applied to the card.

One common approach has been to use a core sheet of sufficient thickness in which are cut openings for receiving the electronic components. The core is laminated between top and bottom layers to enclose these components. Onto this assembly may be applied sheets with pre-printed graphics, and these are in turn covered with protective layers which guard the graphics against wear during handling of the card. The openings in the core sheet are filled to hold the components in place and minimize surface irregularities in the finished card. Various processes are available for this purpose including wet chemistry processes, ultraviolet cured epoxy fillers, self curing fillers, heat cured filler materials, and air cured epoxies among other techniques. These conventional approaches involve many intermediate steps in the manufacture of the cards and require relatively costly and difficult to handle raw materials including very thin plastic sheets of closely controlled thickness. Efforts to simplify card manufacture have been directed to injection molding of carrier cards. Although this method can yield high quality cards it calls for expensive injection molds and production volume is limited by the number of cavities in the molds.

U.S. Pat. No. 5,817,207 to Leighton discloses a hot lamination method whereby a micro-circuit is encapsulated between two discrete sheets of plastic under heat and pressure so that the plastic flows around the electronic device. While in principle this method eliminates the need for a separate core sheet with cut out openings for receiving the microcircuit, it is a very difficult process to carry out in practice and still requires considerable handling and cutting of plastic sheets and loading these into the lamination press one at a time.

In spite of the rapid growth in usage of interactive cards and labels, existing technology for the economical manufacture of those items has failed to keep pace with demand. A continuing need exists for a lower cost method of high volume manufacture of laminar structures, such as cards and labels, with embedded interactive or other elements.

**SUMMARY OF THE INVENTION**

In response to the aforementioned need this invention provides a method for the continuous fabrication of cards or labels containing embedded microcircuits or other interactive elements by extruding continuous upper and lower layers of hot extrudate material, introducing the microcircuit between the upper and lower layers at spaced locations therealong, pressing the upper and lower layers into adhesion with each other while in a plastic state thereby to make a continuous composite sheet having an upper surface and a lower surface and containing the microcircuits suspended in the extrudate material in spaced relationship to both the upper surface and the lower surface, cooling the composite sheet to solidify the hot extrudate material, and cutting out card blanks from the composite sheet, each card blank containing a microcircuit which is preferably consistently positioned from one card blank to the next.

In one form of the invention the microcircuits are introduced between the upper and lower extrudate layers on a continuous carrier sheet, which may be an apertured web permitting adhesive contact between the upper and lower extrudate layers through openings in the web sheet. The carrier sheet may also serve as a substrate for printed circuits interconnecting circuit components in each of the microcircuits.

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In another form of the invention the microcircuits are introduced one by one in discrete fashion between the extrudate layers, as by a vacuum pick and place robotic device. Each of the microcircuits may include a number of circuit components, such as an antenna coil connected to an R.F. transponder microchip. The circuit components may be mounted on a printed circuit substrate such as a printed circuit etched on a thin flexible polyester sheet, or may be naked components with interconnected terminals and no other support, such as an antenna air coil directly connected to a transponder I.C. chip.

Secondary operations may include calendaring the continuous composite sheet thereby to achieve a controlled thickness of the composite sheet and of the card blanks, embossing the continuous sheet thereby to apply a desired surface finish to one or both of the upper surface and the lower surface, printing graphic images on one or both of the upper surface and the lower surface before or after cutting out the card blanks, and punching one or more holes in the continuous sheet in given relationship to each of the microcircuits such that each card blank is cut out with one or more prepunched holes.

Although the extrudate material is not limited to any particular class of materials it is presently contemplated that a synthetic plastic will be employed for this purpose and more specifically the extrudate material is selected from the group consisting of polyvinylchloride, chlorinated polyvinylchloride, polycarbonate, ABS (acetobutylene styrene), nylon and Teflon. The carrier sheet may be of any suitable material such as polyester, F4 glass fiber sheet, PVC, acetate, nylon or Teflon, among other possibilities.

These and other advantages, features and improvements will be better understood from the following detailed description of the preferred embodiments taken in conjunction with the accompanying drawings.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic depiction of the apparatus arranged for practicing the continuous fabrication method of this invention;

FIG. 2 is an enlarged cross sectional detail view showing the upper and lower extruder nozzles applying corresponding upper and lower layers of extrudate to a continuous carrier sheet or web bearing electronic microcircuits;

FIG. 2A is a plan view of a typical composite sheet 40 containing embedded microcircuits 14;

FIG. 3 is a perspective view of a typical finished access control card;

FIG. 4 is a schematic illustration of a production line for webless continuous fabrication of access control cards according to an alternate method of this invention; and

FIG. 5 is an enlarged cross sectional detail view illustrating the webless insertion of discrete microcircuits between upper and lower layers of extrudate.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

With reference to the accompanying drawings wherein like elements are designated by like numerals, FIG. 1 shows a production line generally designated by numeral 10, for the continuous fabrication of access control cards or labels with embedded electronics according to this invention. A web supply roll 11 provides a continuous supply of a web sheet 12 on which have been mounted at regularly spaced intervals microcircuits 14 to be embedded in the access control

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cards. For example, circuits 14 may be radio frequency identification transponder circuits including one or more integrated circuit chips connected to external components such as an antenna coil and capacitors, all mounted on a common printed circuit substrate. However, the term microcircuits is here used broadly and is intended to include any elements whether electronic, magnetic or any other elements or devices, active or passive, which are embedded in a plastic carrier card for any purpose whatsoever. For purposes of this disclosure the term microcircuit is used to designate any device or electronic circuit which cooperates or interacts with another electronic reader system.

The production line 10 includes an optional preheating oven 16, a dual extrusion die 18, a pair of pincher rollers 25, a cooling tank 20 and a cutting press 22 such as a punch press. Depending on the particular cards being produced one or more secondary operation stations may be added such as magnetic stripe applicator 24, embossing or calendaring rollers 26, graphics printing station 28, card numbering press 30 and hole punch 32.

The web 12 passes through preheating oven 16, through dual extrusion die 18 between an upper extrusion nozzle 34 and a lower extrusion nozzle 36, and between pincher rollers 25, as better seen in FIG. 2. Each nozzle typically is a slit opening dimensioned to produce a ribbon of desired width and thickness. Each nozzle 34, 36 extrudes a continuous ribbon 35a, 35b of heated material in a semi-molten plastic state. The extrusion nozzles are at a 45° angle, oriented in the direction of advance of the web sheet 12, and are positioned so that the two ribbons pass between a pair of pincher rollers 25 above and below the carrier sheet 12. The hot extrudate is driven through the nozzles 34, 36 by pressure applied to the molten material in the heated die cavities. Pincher rollers 25 downstream of the extrusion nozzles press the still hot and viscous extrudate ribbons together and against the carrier sheet 12 including microcircuits 14 as the circuits pass between nozzles 34, 36, to form a continuous composite sheet 40 having upper and lower layers 38a, 38b of extrudate material and containing carrier sheet 12 with microcircuits 14. In FIG. 2 three microcircuits 14 are shown at different stages of the encapsulation process. The first microcircuit 14 on the left is being carried on the bare web sheet 12 into the dual extrusion die 18. The middle microcircuit 14 is entering the pinch area between the upper and lower extrudate ribbons 35a, 35b and has been partially encapsulated. The microcircuit 14 on the right hand side has passed between the pincher rollers 25 and has been fully encapsulated in the hot extrudate material. The hot composite sheet 40 is passed through a cooling water tank 20 where the extrudate is cooled to a solid state. The solidified composite sheet 40 is continuously drawn by a puller device such as a pair of driven pincher rollers (not shown in the drawings) downstream of the cooling tank 20 or a large diameter collection drum 42 at the end of the production line 10. The puller device applies continuous controlled pulling force on the ribbons as the hot extrudate emerges from the nozzle openings and on the web sheet. The web sheet 12 is pulled in this fashion through the dual extrusion die 18 and between the extrusion nozzles 34, 36 along with the extrudate ribbons 35a, 35b. The pulling rate is calculated to pull the extrudate ribbons at the same rate as the ribbons are extruded from the nozzles, and to pull the carrier sheet 12 at this same rate.

The thickness of the upper ribbon 38a extruded by the die nozzle 34 is greater than the thickness of the microcircuits 14 on the web sheet 12 so that the microcircuits 14 are fully covered and encapsulated in the extrudate material. The

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viscosity of the extrudate is controlled by means well understood in the trade so that the material flows onto all sides of the circuit 14 and closely encapsulates the microcircuits. The carrier sheet 12 is preferably apertured by perforations in the sheet to permit partial flow-through of hot extrudate and actual contact between the upper and lower layers 38a, 38b of extrudate, so as to assure positive bonding between the extrudate layers and the web sheet. An optional oven 16 may be provided upstream of the dual extrusion die 18 for preheating the carrier sheet 12 and the microcircuits 14 to minimize thermal shock upon contact with the hot extrudate, and so reduce losses of microcircuits to heat damage to improve process yield.

The cooled composite sheet 40 may be collected without further processing in continuous roll form on collection drum 42, to be cut into individual cards and otherwise treated and processed at a later time. Alternatively the punch press 22 cuts out individual cards 50 each containing a microcircuit 14, such as illustrated in FIG. 3, from the continuous sheet 40. The cards 50 are collected in a bin or other suitable collection device (not shown) while the remains of the carrier sheet is collected as scrap, on collection drum 42 or fed into a shredder for recycling. The operation of the punch press 22 is referenced to the position of the individual circuits 14 within the advancing composite sheet so that the individual cards 50 are cut out in register with the embedded circuits 14, i.e. so that the position of the embedded circuits 14 is consistent from card to card. Referencing of the punch press 22 may be achieved by means well understood in the field, such as infrared detection of each embedded circuit 14 ahead of the punch press coupled with rate of movement data derived from a sensor connected to the puller device, so as to time the operation of the punch press 22 with the proper position of the circuit 14 under the punch press. In order to die cut the moving composite sheet 40 either a traveling punch or a conventional accumulator device may be used.

Depending on the type of card, label or similar article being manufactured, one or more secondary operations may be performed as part of this fabrication method. For example a continuous magnetic stripe may be applied to the composite sheet 40 by a magnetic stripe applicator 24, so that each card blank cut from the sheet includes a strip of magnetic material encodable with machine readable digital information. A custom finish may be imparted to one or both surfaces of the card blanks by a pair of embossing rollers 26, such as a polished surface, a wood grain surface, or a matte finish, to name a few possibilities. These two secondary operations are best performed on the continuous composite sheet 40 while it is still in a semi-plastic state, ahead of cooling tank 20, although cold calendaring and embossing are also possible. Additional secondary operations may include application of graphic images such as company logos by a printing station 28. A variety of printing technologies are available for this purpose such as pad printing or die sublimation printers, and is selected according to factors such as desired image quality and cost limitations. Numbering of the cards may be done by hot stamping, laser etching or by an ink jet numbering head at station 30 and a hole punch 32 may be included in production line 10 for punching one or more holes, such as key chain holes, in each card blank.

The web sheet 12 may be pre-punched at a punch station 13 ahead of the dual extrusion die 18 to make apertures or openings in the web sheet. These apertures may include transverse slots 15 spaced along the web sheet 12 as shown in FIG. 2A. The side edges 40a, 40b of the composite sheet 40 are suggested in phantom lining in the Figure. The web sheet 12 is shown in solid lining and it is seen that the width of the web sheet is narrower than the width of the composite

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sheet 40. Each slot 15 is located between consecutive microcircuits along the web sheet and is sized and shaped so as to allow contact between the upper and lower extrudate layers 38a, 38b along at least a portion of the leading and trailing edges 58a, 58b of each consecutive pair of cards 50 (suggested in phantom lining in FIG. 2A) to be cut out from the web sheet. That is, the width of each slot 15 measured along the length of the web sheet is somewhat greater than the spacing between the consecutive cards. This not only allows a margin of contact between the two extrudate layers for good adhesion along all edges of the card, thereby to prevent delamination of the card in use, but also minimizes the edge of the web sheet along the card edges for better esthetic appearance. The length of each slot 15 is somewhat shorter than the width of the web leaving two relatively narrow strips or links 55 connecting each consecutive pair of cards 50, so that in the finished card 50 the web edge shows only along small portions of the card edges. Additional apertures in the web sheet 12 may be punched in a generally central area of the cards 50 for bonding between the upper and lower extrudate layers, such as openings 57 inside an antenna coil 59 connected to integrated circuit chip 61.

FIG. 3 shows a typical access control card 50 made by the method of this invention, with embedded microcircuit 14. The card has a rectangular shape, an imprinted graphic image 52, an imprinted card number 54, and a punched badge dip slot 56. An important advantage of this invention is the ease with which smooth top and bottom surfaces of the card 50 can be obtained, due to the encapsulation of the microcircuit 14 in fluid extrudate material as opposed to the conventional technique of laying sheet material over and under such a circuit. The hot extrudate conforms to the contours of the circuit 14 without residual irregularities on the card surface. If a high degree of precision is desired in the surface smoothness and thickness of the card 50, a pair of calendaring rollers may be provided in lieu of or in addition to the embossing rollers ahead of the cooling tank 20 in FIG. 1. Calendaring of continuous sheet material to achieve tight control of thickness tolerances is well understood in the industry and need not be discussed in greater detail here.

An alternate embodiment of this invention is shown in FIGS. 4 and 5. The production line 10' of FIG. 4 differs from that of FIG. 1 in that the microcircuits 14 are inserted between layers 38a, 38b of hot extrudate in discrete fashion, i.e. individually and without support from a continuous web. Each circuit 14 is pressed into sufficient contact with the extrudate, preferably in the pinch region R where the upper and lower layers 38a, 38b are pressed together between pincher rollers 25 after emerging from the upper and lower nozzles 34, 36 of the dual extrusion die 18, as suggested in FIG. 5. The microcircuits 14 may be inserted one at a time by means of a suitable robotic device such as a vacuum pick-and-place device 42 with robotic arm 42a. When released by the insertion device 42 each microcircuit 14 is carried with the stream of extrudate and, as the continuous ribbons 35a, 35b are pressed together between pincher rollers 25 the microcircuit 14 is captured, coated by and encapsulated between the merging ribbons, and carried within the composite extrudate sheet 40' towards the cooling tank 20.

The microcircuits 14 are typically planar assemblies, i.e., have a main plane with a relatively large surface area. Some microcircuits are mounted on a thin flexible printed circuit substrate sheet. Other circuits 14 may consist of Wiegand strips which are also packaged in planar sheet form. Microcircuit 14 may also consist of only an air coil directly connected to a naked integrated circuit chip such as a radio frequency transponder chip, with no other support or circuit components. Even in such a case the air coil has a planar configuration defining a principal plane of the microcircuit.

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According to the alternate method of this invention discrete individual microcircuits 14 are inserted into the extrudate stream in coplanar relationship to the composite sheet 40' formed by the merging extrudate ribbons 35a, 35b. That is, the principal plane of the circuit 14, such as the circuit board plane, lies parallel to the parallel top and bottom surfaces 42a, 42b of the merged extrudate layers. The substantial surface area presented by the principal plane of each microcircuit 14 in a direction transverse to the length of the extruded sheet 40' ensures that the microcircuits have little tendency to drift up or down through the viscous extrudate and will tend to remain at a predictable location intermediate the top and bottom surfaces 42a, 42b of the extruded composite sheet 40'. In effect each microcircuit 14 is self-centering between the top and bottom surfaces of the composite extrudate sheet 40'. Control over the positioning of the circuit between the top and bottom surfaces 42a, 42b may be had by altering the relative thicknesses of the upper and lower extrudate ribbons 35a, 35b by appropriate modification to the dimensions of extrusion nozzles 34, 36. By making the lower layer relatively thin and increasing the thickness of the upper layer 35a, the resulting location of the circuit 14 is shifted closer to the bottom surface 42b of the composite sheet and consequently closer to the bottom surface of the finished card. Conversely, the circuit 14 can be positioned closer to the top surface of the card by diminishing the relative thickness of the upper layer 38a in relation to the lower layer 35b.

The finished cards made according to the alternate method of FIGS. 4 and 5 are essentially similar to the card 50 in FIG. 3 obtained by the webbed method of FIGS. 1 and 2, except for the absence of a web layer in the finished card.

As was mentioned earlier it is particularly desirable to make thin access control cards having a thickness comparable to that of ordinary credit cards. Typical credit card components include a 28 mil thick inner sheet of white PVC plastic and a 1.5 mil clear overlay to protect printed graphics on each side, the three layers laminated under heat and pressure, the resulting laminate being about 31 mils thick. Microcircuits 14 may include so called "flip-chip" integrated circuits having a thickness of the order of 15 to 20 mils, for example, mounted on very thin, e.g. 2 mil thick, flexible printed circuit sheets of Kapton or polyester, for example, with antenna coils etched on the printed circuit sheets. The combined thickness of the extrudate ribbons 35a, 35b need be only slightly greater than the thickness of the microcircuits 14 so as to cover the top and bottom of the microcircuits. In the method of FIGS. 1 and 2 the upper extrudate ribbon 35a must be sufficiently thick to cover the entire thickness of the microcircuits 14, while the lower extrudate ribbon 35b may be relatively thin as it only needs to cover the underside of the carrier sheet 12. If the carrier sheet 12 is perforated, extrudate material from the bottom layer may pass through the sheet 12 and contribute to adhesion to the top side of the sheet 12. In the alternate method of FIGS. 4 and 5 the upper and lower extrudate ribbons 35a, 35b may be of comparable thickness as there is no carrier sheet between the two layers and each ribbon may contribute about one half the total thickness of the card being made. It is presently preferred that the web 12 be narrower than extrudate layers 38a, 38b and in fact narrower than the width of the cards being made, so that the web sheet does not show along the cut edges of the cards. The extrudate ribbons may be approximately 2.5 inches wide to provide ample margins on either side of a typical 2.125 inch wide card.

An important feature of this invention is that it is very easy to change the thickness of the extrudate ribbons simply by changing nozzles at the extrusion die, a relatively quick

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procedure, so that cards, labels or other similar items of different thicknesses can be readily fabricated depending on the purpose of the card and the size of the encapsulated microcircuit 14. No inventory of sheet materials needs to be kept on hand or ordered. A continuous range of card thicknesses can be obtained as needed and is not limited by availability of particular sheet thicknesses. As a result it is possible to precisely tailor the card thickness to the encapsulated microcircuit 14 and thereby minimize card thickness for a given microcircuit.

From the foregoing it will be appreciated that a first and an alternate method have been disclosed for the continuous manufacture of access control cards with embedded microcircuits with superior control over card materials, card thickness and surface finish, yet at lower unit cost than is possible today. The disclosed methods provide single step manufacture of the cards and can be implemented on a production line run by a single operator, as opposed to the many step, many operator methods currently practiced.

While particular embodiments of this invention have been described and illustrated for purposes of clarity and explanation it will be understood that many changes, substitutions and modifications to the described embodiments will be apparent to those having no more than ordinary skill in the art without thereby departing from the scope of the following claims.

What is claimed as new is:

1. A method for the continuous fabrication of electronic access control cards, comprising the steps of:

extruding continuous upper and lower layers of hot extrudate material;

introducing a continuous carrier sheet between said upper and lower layers, said carrier sheet bearing microcircuits at spaced locations therealong;

pressing said upper and lower layers into adhesion with each other while in a plastic state thereby to make a composite sheet of substantially constant thickness having an upper and a lower surface and containing said microcircuits suspended in said extrudate material in spaced relationship to both said upper and said lower surface;

cooling said composite sheet to solidify said hot extrudate material; and

cutting said composite sheet thereby to cut out access control card blanks containing a microcircuit in substantially consistent relative position in each card blank;

characterized in that said carrier sheet is narrower than said composite sheet and has openings between consecutive ones of said microcircuits in said continuous carrier sheet, said openings having a length somewhat shorter than the width of said carrier sheet and a width measured along the length of said web sheet somewhat greater than the spacing between consecutive ones of said card blanks thereby to allow contact between said upper and lower layers for bonding along all edges of said card and to limit the web edge to show only along small portions of card edges for improved esthetic appearance and prevent delamination of the card in use, and additional openings in said carrier sheet to permit bonding of said upper and lower layers to each other at additional locations between said edges of said card.

\* \* \* \* \*

# (12) UK Patent Application (19) GB (11) 2 225 283 (13) A

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(51) INT CL<sup>4</sup>  
B42D 15/02 15/10, G06K 19/06 19/077

(52) UK CL (Edition J)  
B6A AC91 AK

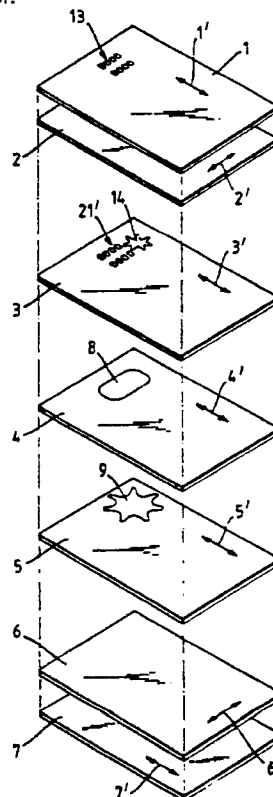
(56) Documents cited  
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(58) Field of search  
UK CL (Edition J) B6A AK  
INT CL<sup>4</sup> B42D  
Online database : WPI

## (54) Laminated IC card

(57) A laminated, integrated circuit (IC) card comprises a number of plastics layers (1-7) laminated together and supporting an IC element (8). Some of the plastics layers (1-7) exhibit a grain structure and at least two of the layers (2, 3); (5, 6) are oriented with their grain directions transverse to each other.

Fig. 1.



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

The claims were filed later than the filing date within the period prescribed by Rule 25(1) of the Patents Rules 1982.

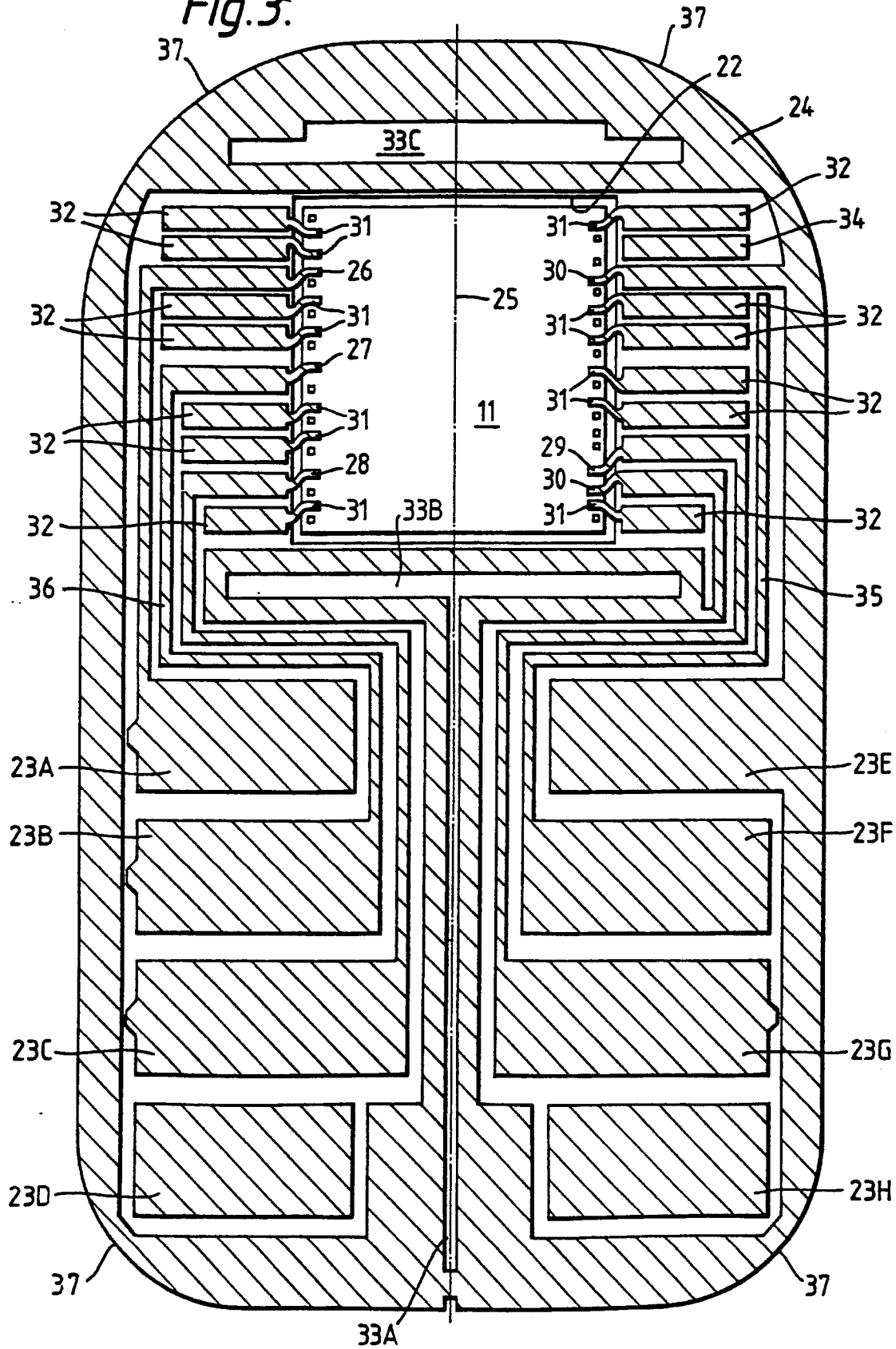
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*Fig. 3.*





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LAMINATED IC CARD

The invention relates to a laminated integrated circuit (IC) card comprising a number of plastics layers  
5 laminated together and supporting an IC element. Such a card is hereinafter referred to as of the kind described.

Cards of the kind described are being used in a wide variety of fields, for example as credit and charge cards as well as identification cards and the like. These  
10 cards include an IC element, typically a single chip microprocessor, which in most cases is mounted to a carrier element to form an IC carrier assembly. This assembly is then laminated into the plastics layers. One of the problems with these cards is that during use  
15 they undergo significant flexure which can cause some of the layers to crack and possibly also damage the IC element.

According to the present invention, we provide a laminated IC card of the kind described in which at least  
20 some of the plastics layers exhibit a grain structure, and wherein at least two of these layers are oriented with their grain directions transverse to each other.

Typical IC cards have a generally rectangular form and it has been found that the resistance to flexure and  
25 hence the likelihood of cracking varies between the short and long dimensions of the card. We have found that this can be improved upon by taking account of the inherent grain structure of certain plastics layers. Thus by orienting at least two of the layers with their  
30 grain directions transverse, the susceptibility to cracking is reduced.

The grain structure originates from the method of manufacture of the layers in which the layers may be rolled and calendered causing some degree of molecular  
35 alignment within the plastics materials.

Preferably, the grain directions of the two layers are arranged orthogonally to each other.

In one example, a majority of the plastics layers which exhibit a grain structure are arranged with their grain directions substantially parallel with a minority of the plastics layers exhibiting a grain structure having their grain directions transverse to the one direction.

Since the stiffness of a layer increases with the third power of the thickness, it is preferable if one of the said two layers is chosen from the thickest layers. Typically, the thickest layers are those which normally carry printed information.

Typically, the plastics layers comprise PVC although other types of plastics such as PVCA could be used.

In a further improvement, the card may further comprise at least one stress reduction member positioned in alignment with the IC element and having a grain direction oriented substantially parallel to the grain direction of at least one of the plastics layers. The use of a stress reduction member is described in more detail in our copending European Patent Application entitled "Integrated Circuit Card" (Agents Ref:30/2470/02) filed on even date and in the preferred example this member is in the form of a star-shaped, metal member.

In one construction, the grain directions of alternate plastics layers alternate between one of two transverse directions.

An example of an integrated circuit card in accordance with the present invention will now be described with reference to the accompanying drawings, in which:-

Figure 1 is an exploded view of the card;

Figure 2 is a perspective view of the IC module;

Figure 3 is a plan of the conductor pattern provided on the carrier element of the IC module; and,

Figure 4 is an enlarged cross-section through part of the card.

5 The integrated circuit card comprises a laminate, as shown in Figures 1 and 4, having a number of plastics layers 1-7. The plastics layers 1-7 typically comprise PVC, PVCA or similar materials. The thickness of these layers is set out in Table 1 below.

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TABLE 1

Layer Number	Pre-lamination Thickness ( $\mu\text{m}$ )
(1)	60
(2)	150
15 (3)	120
(4)	120
(5)	250
(6)	150
(7)	60

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After lamination, the total thickness of the card will reduce to about 780 $\mu\text{m}$ .

Each layer has a grain due to the method of manufacture in which the sheets are rolled and calendered causing some alignment of the molecular structure. Consequently, each layer is "stiffer" across the grain than along the grain. The grain direction of each layer is indicated in Figure 1 by arrows 1' - 7' respectively and it will be seen that the grain direction of layers 2 and 6 is transverse to that of the remaining layers. These layers 2,6 are typically opaque and carry printing on their outwardly facing surfaces. Due to their thickness relative to the other layers and their positions towards the outside of the card there is a significant risk of cracking of these two layers when the

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card is bent in its short dimension, if the grain of these layers were in the long dimension. The reason for changing the grain direction in these layers is that this leads to a card in which there is a much lower risk of cracking of the printed layers. Also, a generally similar degree of resistance to flexure in all directions is achieved. These improvements lead to a longer lifetime. If all the laminae were to be laid with the grain in the same direction, then the result would be a "stiff" card in the axis across the grain. This is undesirable since, from a bending/torsion viewpoint, it is preferred that the card is equally flexible in all directions relative to the "stress reduction" members of the IC Module (to be described).

15 In the case of plastics layers 1-7 formed by rolling and/or calendering, the "grain" is considered to extend in the long direction of the forming process, ie. the direction of movement of the plastics through the forming apparatus. Typically, this is the predominant direction of shrinkage when the plastics is subjected to heat.

20 Embedded within the card is an IC module 10 (Figure 2) consisting of a chip 11 defining a single chip microprocessor such as the Hitachi 65901 mounted to a chip carrier 12 formed by a layer of copper 12A on a polyimide layer 12B such as Kapton to define a carrier assembly. The chip carrier 12 is received in an aperture 8 of the layer 4. As will be explained in more detail below, a pair of star shaped stress reduction members 15, 16 are embedded in apertures 14, 9 respectively of the layers 3, 5 in alignment with the chip 11.

30 As will be explained in more detail below, contacts on the chip 11 are coupled via conductors of the copper layer 12A on the chip carrier 12 with contact members 21

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which protrude through the layers 1-3 to allow physical contact with a card reader.

In the finished card, the layers 1, 7 are transparent to allow the printing on layers 2, 6 to be read by the user.

The module shown in Figure 2 is constructed as a separate unit which is then laminated with the layers 1-7. The chip carrier 12 is cut from a Kapton (polyimide) substrate 12B (thickness 75 $\mu$ m) on which is provided the layer 12A of copper foil (thickness 35 $\mu$ m) adhered by an epoxy to the Kapton layer 12B. The copper is etched to provide a conductor pattern shown in more detail in Figure 3. In addition the Kapton is punched to provide an aperture 22 in which the chip 11 is received.

It will be seen in Figure 3 that the conductor pattern defines eight contact pads 23A-23H to which the contact members 21 are individually bonded. In addition, the conductor pattern has an outer ground plane 24 extending around the pattern. It should be noted that the contact pads 23A-23H are substantially symmetrically arranged about a line of symmetry 25.

The contact pad 23A is connected with a functional contact 26 of the chip 11; the contact pad 23B is connected to a functional contact 27 of the chip; the contact pad 23C is connected to a functional contact 28 of the chip, and the contact pad 23G is connected to a functional contact 29 of the chip 11. Two functional contacts 30 are connected to the ground plane 24 as is the contact pad 23E. Contact pads 23D, 23F and 23H are isolated.

In addition, a number of non-functional contacts 31 of the chip 11 are connected to respective, short conductors 32 of the conductor pattern such that the arrangement of the conductor pattern adjacent to the chip

11 is substantially symmetrical about the line of symmetry 25. In addition, an isolated conductor 34 is provided to complete the symmetrical arrangement.

In this case, it will be seen that the conductor pattern is bonded to ten contacts of the chip 11 on the left hand side of Figure 3 and nine contacts on the right hand side. This small difference in the number of bonded contact positions is acceptable and the term "substantially symmetrical" should be interpreted accordingly. This substantially symmetrical arrangement of contacts connected to conductors allows the chip 11 to be securely supported in the aperture 22 of the carrier 12 and reduces the risk of undue twisting of the chip 11 within the aperture 22, whilst allowing some freedom of movement of the chip relative to the chip carrier 12. This freedom of movement is necessary to prevent damage to the chip and its connections during manufacture of the IC module 10, during lamination of the IC card, during subsequent use of the IC card. Undue twisting of the chip 11, in the aperture 22, relative to the chip carrier 12 could result in excessive stresses at the IC connections.

The remainder of the conductor pattern is also substantially symmetrical about the line of symmetry 25. In this connection, it should be noted for example that although the contact pad 23F is not connected to the chip 11, a conductor line 35 extends from the contact pad 23F to a position adjacent the chip 11 in a similar way to a conductor line 36 which extends from the contact pad 23B to the contact 27. This assists in overcoming the natural tendency of the copper layer 12A to distort, which can otherwise weaken the bonds between the conductors and chip contacts before lamination, during lamination, and to some extent after lamination.

In addition, the copper pattern 12A is split at 33A, 33B, 33C to reduce its rigidity, so that the chip carrier 12 will more readily flex when card flexure occurs. The copper pattern is split at 33A along the line of symmetry  
5 25, copper is etched away from a section 33B orthogonal to and communicating with the section 33A, copper is also etched away from a section 33C.

The corners 37 of the carrier 12 are rounded to help to reduce stress concentrations in the card layers at the  
10 corners of the carrier.

In constructing the module, the first step is to form the conductor pattern described above. The next step is to bond the contact members 21 to the contact pads 23A-23H.

15 Following this step, the IC chip 11 is located in the aperture 22 and the chip contacts are bonded to the inner ends of the conductors which overlie the aperture 22, as shown in Figure 3 and as previously described. The method chosen is Tape Automated Bonding (TAB). TAB  
20 is preferred to wire bonding since (relative to wire bonding) it provides higher bond strength, greater reliability, improved mechanical construction, and a thinner package.

TAB requires that the IC chip 11 should have its  
25 contacts "bumped" to a specified height and consistency to allow for the inner lead bonding of the chip to the carrier. The bumping normally comprises the deposition of gold onto the aluminium contacts of the chip.

After the bonding operation, a resin (polyurethane)  
30 coating 50 (Figure 4) is applied to the surface of the IC chip 11 and the inner lead bonds so as to provide for mechanical and optical protection for the chip contact/conductor bonds prior to lamination. This coating 50 is known as the "glob top".

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The two star shaped members 15, 16 are then bonded to the chip carrier 12. These members 15,16 are metal and are consequently stiffer than the plastics layers 1-7. The members 15, 16 locally stiffen the card body around the chip 11, they provide a strengthening reinforcement to protect the contact/conductor bonds. The members 15, 16 are stress reduction members reducing the mechanical stresses to which the contact/conductor bonds are subject during card lamination and during card use. To avoid abrupt changes in the card stress conditions, introduced by the members, at the boundaries of the members with the card laminae a "star" shape is adopted as shown in Figure 2. The star profile provides a gradual increase in stiffness from the outer boundary of legs 40 of the star to a central section 41 indicated by a dotted line.

It should be noted that the "stiffness" of a circular plate varies inversely as the square of the diameter and directly as the cube of the thickness.

The members 15, 16 are mounted above and below the chip 11 and it is considered advantageous not to bond the members to the laminate in order to allow relative movement between the members and the laminate during flexing and twisting of the card.

The members 15, 16 are affixed to the chip carrier 12 via respective flexible double-sided adhesive tapes 51, 52 although other forms of flexible bonding could be used. However, it is important that the method used to bond the upper member 15 to the chip carrier 12 is electrically insulating since the upper member 15 contacts the conductor pattern.

In this example the upper member 15 is made of hard-rolled brass and has a thickness of about 50µm. The lower member 16 is made of hard-rolled brass with a thickness of about 150µm. The thicker lower member 16

enables an air pocket to be provided around the chip 11 by providing a machined recess 53 (Figure 4) to accommodate that portion of the chip 11 which protrudes below the chip carrier 12.

5 In other examples, other metals such as stainless steel or coppernickel alloy could be used. In addition the upper member 15 could be in a different metal such as stainless steel to the lower member 16 such as brass. Furthermore, the lower member 16 could be formed similar  
10 to the upper member 15 with a thickness of about 50 $\mu$ m and without a recess. In this case the resulting space would be filled with a suitable material such as a double sided adhesive tape, which will allow a cavity to be formed to accommodate that portion of the chip 11 that  
15 protrudes below the chip carrier 12 and, furthermore which will allow a flexible bonding to the lower member 16 and to the chip carrier 12.

It has been found that it is not necessary to cut an aperture in the double-sided adhesive tape 51 used to  
20 attach the upper member 15 to accommodate the glob-top 50 since the tape is sufficiently flexible to allow the glob-top to be impressed into it (during card lamination).

It should be noted that in the case of the members  
25 15, 16 both being of the same thickness of about 50 $\mu$ m then the typical thickness of each double-sided tape is 85 $\mu$ m for the upper member and 200  $\mu$ m for the lower member 16. It should be noted that in the case of the upper member 15 having a thickness of about 50 $\mu$ m and the lower  
30 member 16 having a thickness of about 150 $\mu$ m then the typical thickness of each double-sided tape is 85 $\mu$ m for both members 15, 16.

It will be noted that each member 15, 16 has an odd number of legs 40 (in this example 7) so as to avoid an  
35 "axis of stress" being set up in the card laminae and

extending through the star centre. This also allows the legs 40 of the upper member 15 to fit conveniently with the contact members 21.

In this example, the diameter of the central section 41 of the upper member 15 is made to correspond to the diagonal dimension of the chip 11, for example 9mm and the outer boundary (defined by the tips of the legs 40) is 13mm to suit the width of the chip carrier 12 and the contact arrangement. For the lower member 16, the central section is made to correspond to the width of the chip carrier 12 and has a diameter of about 15mm and the outer boundary is made to suit the card boundaries with a diameter of about 21mm. Preferably, the two members 15, 16 are positioned so that the legs 40 do not align, in order to avoid possible stress concentrations.

In most examples, each member 15, 16 will have a constant thickness but in some cases, some tapering could be provided from the inner annulus towards the legs.

The completed module 10 (Figure 2) is then assembled with the PVC card layers 1-7 within which it is to be laminated. The module is located in a punched aperture 8 in the layer 4 which is shaped to conform to the chip carrier 12. The layer 5 has a punched star-shaped aperture 9 conforming to the lower member 16 while the layer 3 has a punched aperture 14 having a star-shape conforming to the upper stress reduction member 15 and a set of eight punched apertures 21' through which the contact members 21 protrude. In addition, the layers 1, 2 have sets of eight punched apertures, one set of which is shown at 13 through which the contact members 21 extend so as to finish substantially flush with the outer surface of the layer 1.

It will be noted that the orientation of the chip carrier 12 is transverse to the long axis of the layers

1-7. This orientation is best, from the point of view of card bending/torsion.

The assembled pre-laminate including the module is then laminated using conventional lamination machinery (heated presses). The normal (plastic identification card) lamination technique is to place the lamina build-up into a pre-heated press and immediately apply full pressure (compressing the lamina sheets together). In an alternative method, the applied pressure is gradually increased. For example, the press may be pre-heated to 140°C and then pressure applied in steps. Finally, the laminate is cooled for about 10 minutes with the pressure maintained at its highest value.

It is important that during the lamination process the chip 11 and the contact/conductor bonds are not subjected to undue compressive stresses due to bending. The silicon material has a compressive breaking stress of 15000 lb per square inch but the tensile breaking stress is only 3000 lb per square inch.

The members 15, 16 provide the major resistance to undesirable tensile stresses within the chip 11 and the contact/conductor bonds but in addition use is made of the "pocketing" of the chip in an air filled cavity as defined by the machined recess 53 in the lower member 16. This is because the surrounding gas (air) is readily compressible and will therefore transport the compression forces during laminating uniformly to the chip without subjecting the chip 11 to undesirable tensile stresses due to bending.

The preferred stress reduction members 15, 16 are made from metals, such as hard-rolled stainless steel and brass which exhibit a grain. This causes the members to take up a natural curvature, due to the hard rolling method, which is "memorised" even when the member is flattened. To optimise performance, therefore, it is

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preferred if this grain extends across the card, that is  
parallel with the short dimension of the card, while the  
natural bow or curvature of both members 15, 16 is  
outwardly of the card. The grain direction of the  
5 members 15, 16 is indicated in Figure 2 by arrows 54.

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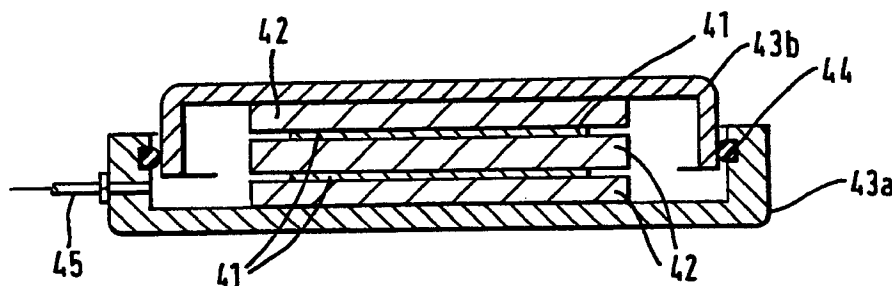
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CLAIMS

1. A laminated, integrated circuit (IC) card comprising a number of plastics layers laminated together and supporting an IC element, in which at least some of the plastics layers exhibit a grain structure, and wherein at least two of these layers are oriented with their grain directions transverse to each other.
2. A card according to claim 1, wherein the grain directions of the two layers are arranged orthogonally to each other.
3. A card according to claim 1 or claim 2, wherein a majority of the plastics layers which exhibit a grain structure are arranged with their grain directions substantially parallel with a minority of the plastics layers exhibiting a grain structure having their grain directions transverse to the one direction.
4. A card according to any of the preceding claims, wherein the plastics layers comprise PVC.
5. A card according to any of the preceding claims, further comprising at least one stress reduction member positioned in alignment with the IC element and having a grain direction oriented substantially parallel to the grain direction of at least one of the plastics layers.
6. A card according to claim 5, wherein the or each stress reduction member comprises a star-shaped, metal member.
7. A card according to any of the preceding claims, wherein the grain directions of alternate plastics layers alternate between one of two transverse directions.
8. A laminated, integrated circuit card substantially as hereinbefore described with reference to the accompanying drawings.

**(12) UK Patent Application (19) GB (11) 2 279 610 (13) A****(43) Date of A Publication 11.01.1995****(21) Application No 9313747.9****(22) Date of Filing 02.07.1993****(71) Applicant(s)****GEC Avery Limited****(Incorporated in the United Kingdom)****Smethwick, WARLEY, West Midlands, B66 2LP,  
United Kingdom****(72) Inventor(s)****Charles Richard Jarvis****(74) Agent and/or Address for Service****Roger Keith Tolfree****GEC Patent Department, Waterhouse Lane,  
CHELMSFORD, Essex, CM1 2QX, United Kingdom****(51) INT CL<sup>6</sup>****G06K 19/077 , B32B 31/20****(52) UK CL (Edition N )****B6A AC91 AK****(56) Documents Cited****GB 2225283 A****(58) Field of Search****UK CL (Edition L ) B6A AK****INT CL<sup>5</sup> G06K****ONLINE DATABASES : WPI****(54) A method of manufacturing a laminated integrated circuit or smart card.**

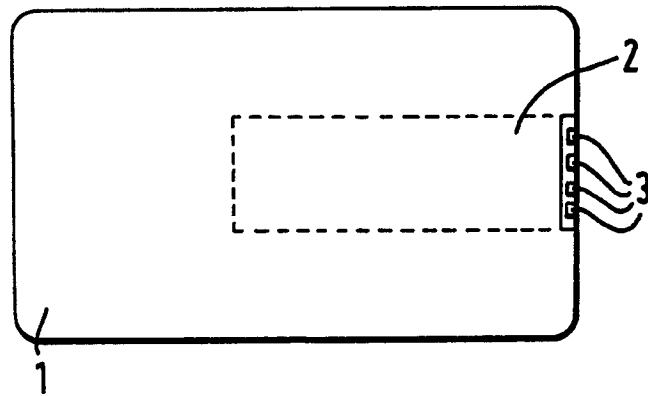
**(57)** A method of laminating a smart card comprises placing together a printed circuit having components thereon and a sheet of thermoplastics material and forming a laminated card therefrom in a vacuum at an elevated temperature such that the components become embedded in the sheet, the vacuum preventing pockets of air being trapped in the process. The pressing process includes a number of stages to prevent the components on the circuit being crushed. The process includes an intermediate pulsed press pressure stage whilst the thermoplastics material is soft, followed by an increased pressure and temperature stage. Cooling is effected under press pressure. The layers 41 to be assembled are placed between pressing plates 42 in pressing case 43a, b connected to vacuum by line 45.

**FIG. 12****GB 2 279 610 A**

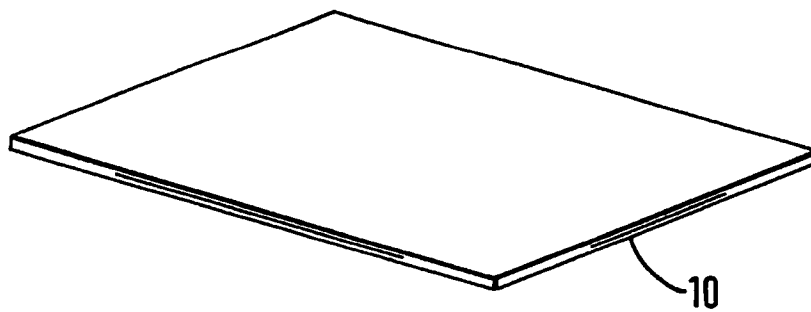
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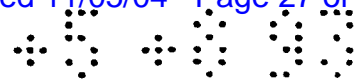
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*FIG. 1*



*FIG. 2*





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FIG. 3

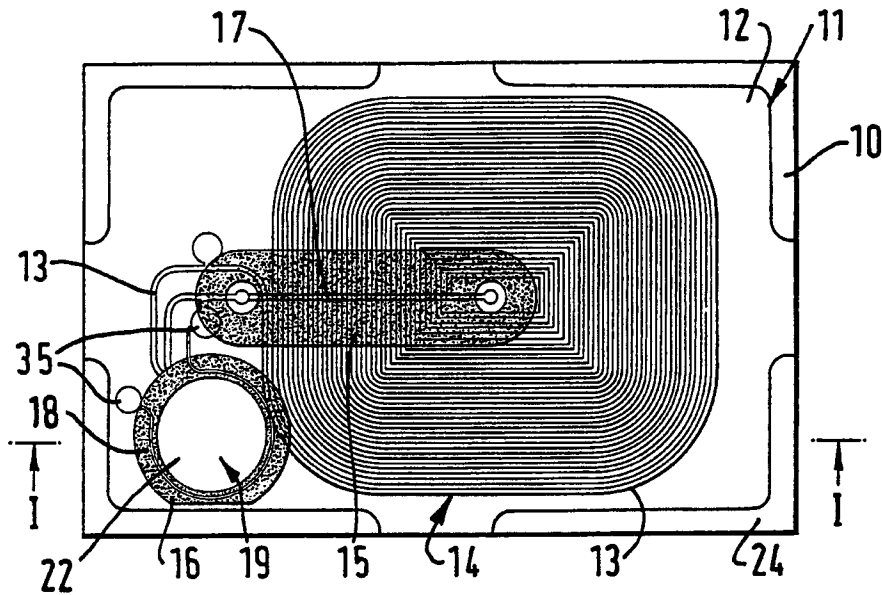
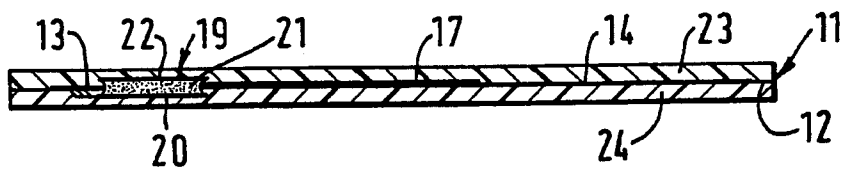
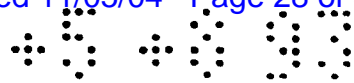


FIG. 4





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FIG. 5

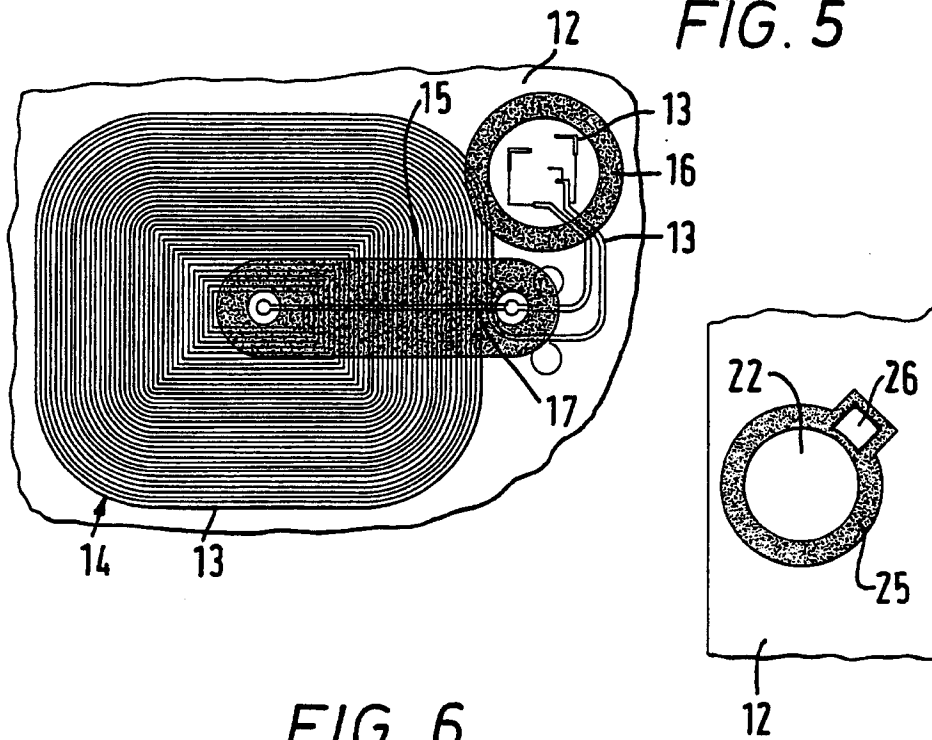
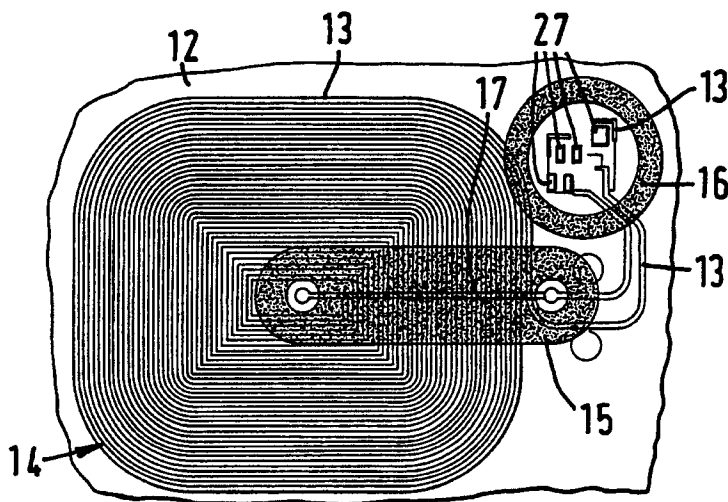


FIG. 6



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FIG. 7

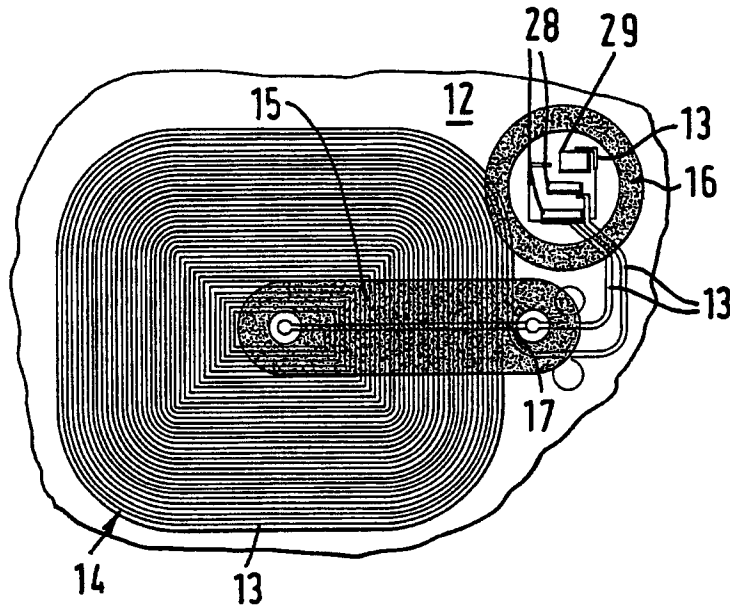
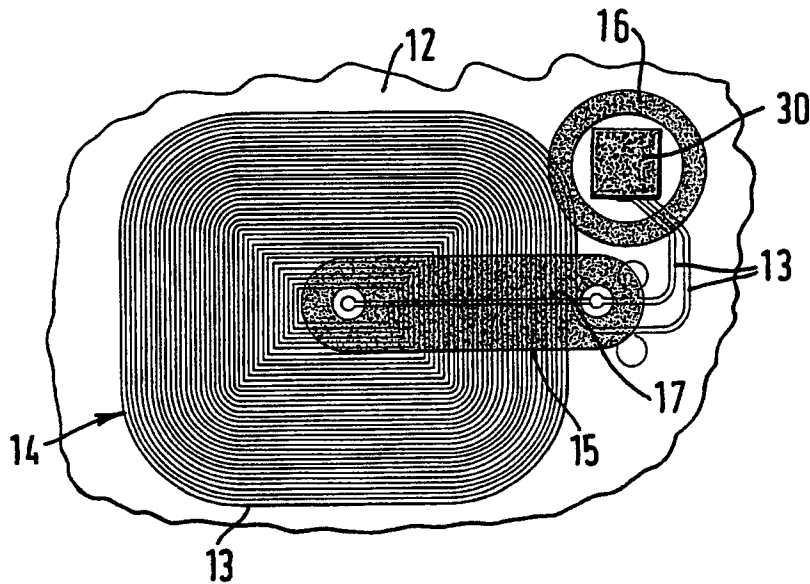


FIG. 8





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FIG. 9

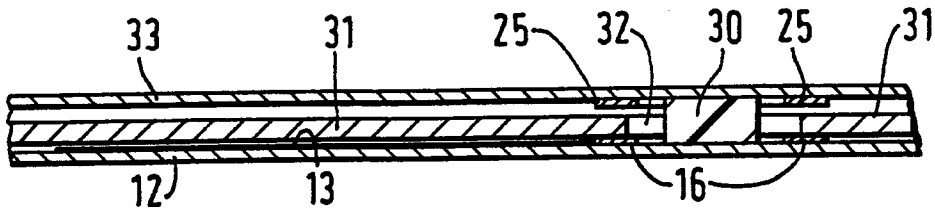


FIG. 10

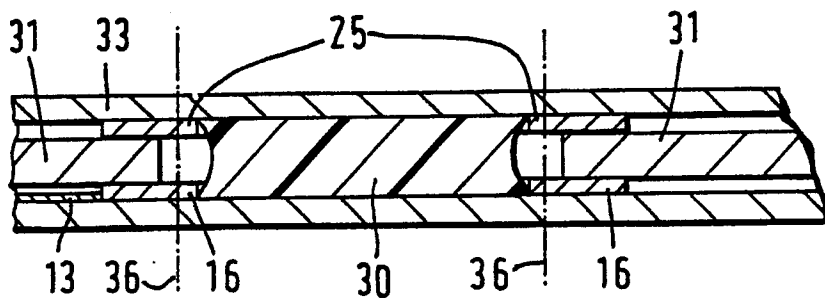
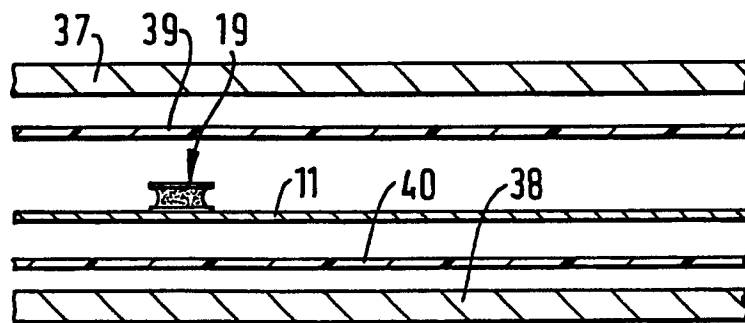


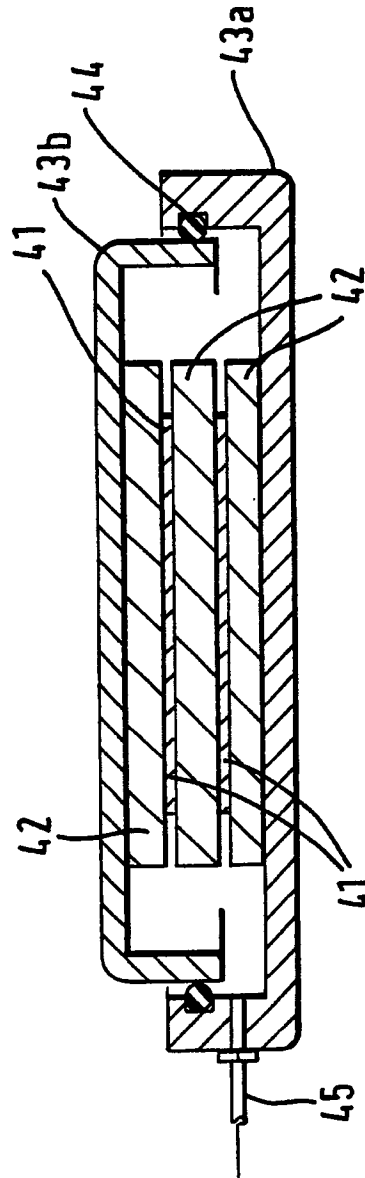
FIG. 11





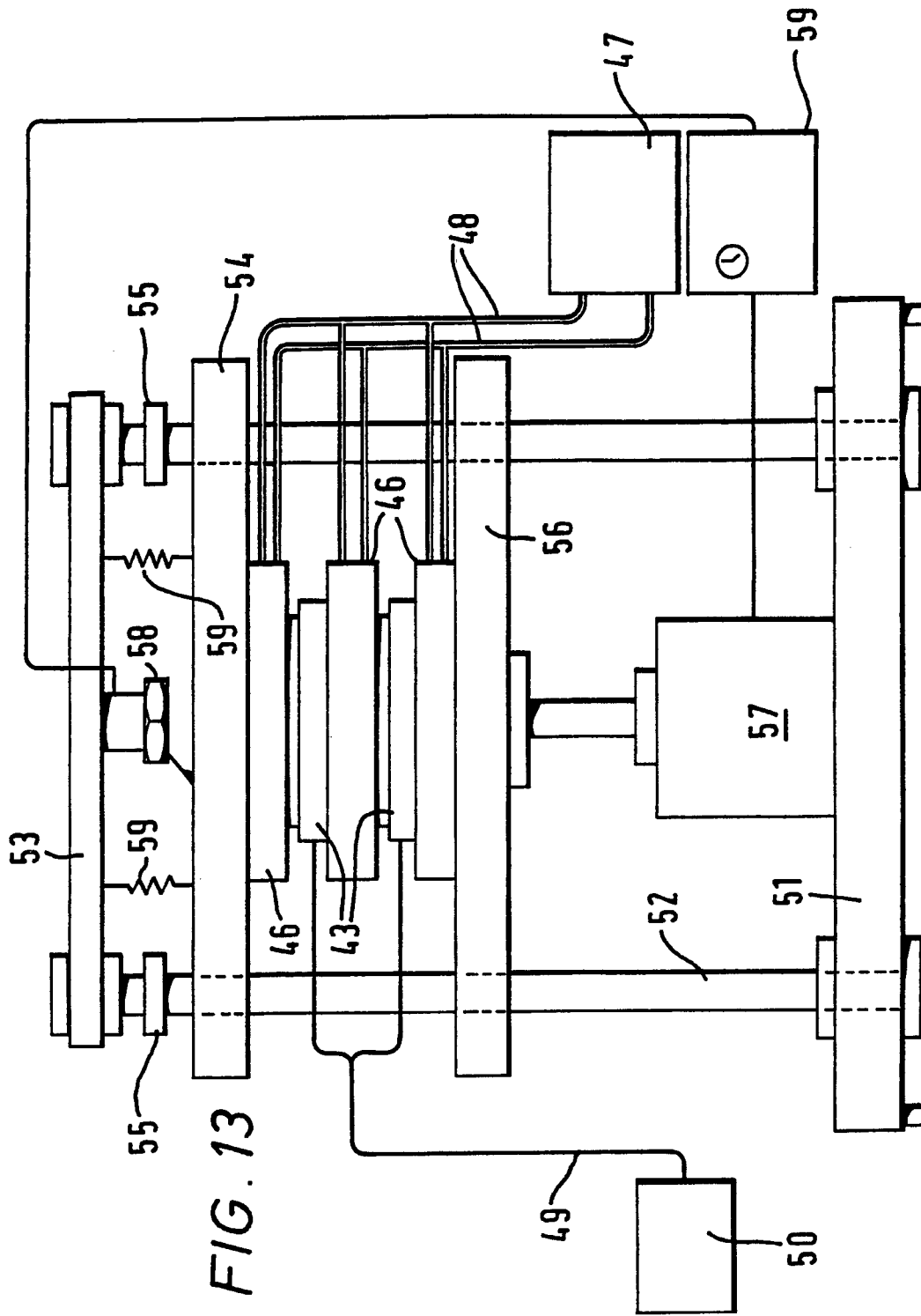
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FIG. 12



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**2279610**

- 1 -

**A METHOD OF MANUFACTURING A LAMINATED CARD**

This invention relates to a method of manufacturing a card comprising a printed circuit having a protective layer on at least one side and in particular, but not exclusively, to the manufacture of what are commonly referred to as "smart cards", that is "plastic cards" incorporating electronic components which are carried by individuals and used for such purposes as recording or authorising transactions and/or for authorising entry to buildings. (Note that the term "printed circuit" as used in this specification should be considered to refer to any system of conductive tracks on an insulating substrate, whether such tracks are formed by printing, etching, vapour deposition or any other technique.)

One previously proposed type of "smart card" is illustrated in Figure 1 and comprises a plastic carrier card 1 in which is embedded a printed circuit carrying various components, connections being made by contacts 3 with a suitable communications unit. In such cards the printed circuit 2 which is embedded below the surface of the card is normally relatively small compared to the total surface area of the card. However there is now a requirement for larger printed circuits within cards, particularly if the card communicates with external circuitry by means of an inductive loop embedded within the card, for it is desirable that the loop be as large as possible and therefore almost the whole area of the card is required for the printed circuit. The present invention provides a method of fabricating such a card.

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According to the present invention there is provided a method of manufacturing a laminated card one layer of which comprises a printed circuit having components thereon, the method comprising placing the printed circuit and a sheet of protective thermoplastic material together in a press, evacuating and heating the sheet and the printed circuit, and pressing the printed circuit and sheet together such that components on the printed circuit become embedded in the sheet of protective material.

It has been found that by employing the present invention and evacuating the printed circuit/thermoplastic sheet during the lamination process, problems with prototype cards de-laminating, which were produced at normal atmospheric pressure have been overcome. It is believed that these prototype cards de-laminated due to pockets of air being trapped around components on the card as the thermoplastic protective sheet softened, these pockets of air tending to expand with time after being removed from the press which not only affects the structural integrity of the card but also makes the card unsightly.

Preferably the printed circuit is sandwiched between two sheets of protective material and advantageously a number of printed circuits are formed on a common substrate wherein a sheet, or both sheets, of the protective material extend over several circuits, the cards being cut from the resulting laminated structure after pressing. In this way a batch of cards can be produced from a single laminated structure. It is also convenient to produce a number of printed circuits on a common

- 3 -

substrate.

Preferably between the printed circuit and sheet of protective material there is placed an intervening layer and this intervening layer is coated with an adhesive which bonds the protective layer to the printed circuit. It is particularly advantageous if this adhesive is a thermally activated catalyst adhesive, for this will not start to cure until the laminated structure is heated in the press.

Preferably the pressing process comprises: closing a press until the sheet of thermoplastic protective material is in thermal contact with a heating unit; and applying a greater pressure once the thermoplastic material has softened. If the greater pressure were applied immediately before the thermoplastic material had time to soften then components on the printed circuit would effectively be crushed by the hard thermoplastic material. This is advantageously achieved by closing the press until a resiliently mounted reaction platen of the press is displaced, for most of the weight of the reaction platen will be supported by the resilient mounting, wherein once the said greater pressure is applied the reaction platen comes into contact with mechanical stops. Preferably the pressure and temperature are again increased for once the pressure has been increased the first time, better thermal conductivity is gained and the temperature can be raised to a level which actuates the curing process.

It is particularly advantageous if the pressure applied by the press is pulsed as this assists in the bedding in of components on the printed circuit into the

- 4 -

thermoplastic material. It is also advantageous to cool the resultant laminated structure whilst still under pressure.

Preferably the sheet of protective material and printed circuit are placed together between a base portion and cover portion of a pressing case which portions are arranged to slide relative to each other on the action of the press, the pressing case comprising a seal between the portions and an outlet by which the pressing case can be evacuated, this enabling the elements of the card to be laminated to be assembled in the case which can be evacuated, and preferably a plurality of sets of printed circuits and protective sheets are contained within a single case each set being separated by a rigid plate ensuring each set ends up with the same surface profile as the rigid plate which would normally be planar. Preferably a number of pressing cases are assembled between the platens of a press with a substantially incompressible heating unit placed between each adjacent pair of pressing cases in the press.

One embodiment of the invention will now be described, by way of example only, with reference to Figures 2 to 13 of the accompanying drawings in which like numerals have been used to indicate like parts, and of which:

Figure 1 schematically illustrates a previously proposed arrangement (not in accordance with the invention) of electrical components in a plastic card;

Figure 2 is a perspective view of a plastic card produced by a method in